LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA1 | Euston - Station and Approach

Flood risk assessment (WR-003-001)

Water resources

November 2013

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Department for Transport

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High Speed Two (HS2) Limited,
Eland House,
Bressenden Place,
London SW1E 5DU

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise three parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).

1.1.2 Specific appendices for each community forum area (CFA) are also provided. For the Euston – Station and Approach area (CFA1), these are:

- a water resources assessment (Volume 5: Appendix WR-002-001); and
- a flood risk assessment (i.e. this appendix).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5, Water Resources and Flood Risk Assessment Map Book.

1.2 Scope and structure of this assessment

1.2.1 This flood risk assessment (FRA) considers the assessment of flood risk in CFA1. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1] which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.

1.2.2 The FRA methodology and a review of the relevant local planning policy documents are provided in Section 2 of this report. The design criteria are provided in Section 3 and Section 4 documents the sources of information that have been reviewed. Section 5 provides a description of the planned works within CFA1. Section 6 considers baseline flood risk and the risk of flooding to the Proposed Scheme from all relevant sources. Flood risk mitigation measures included within the Proposed Scheme are detailed in Section 7. The effect of the Proposed Scheme on the risk of flooding is considered in Section 8.

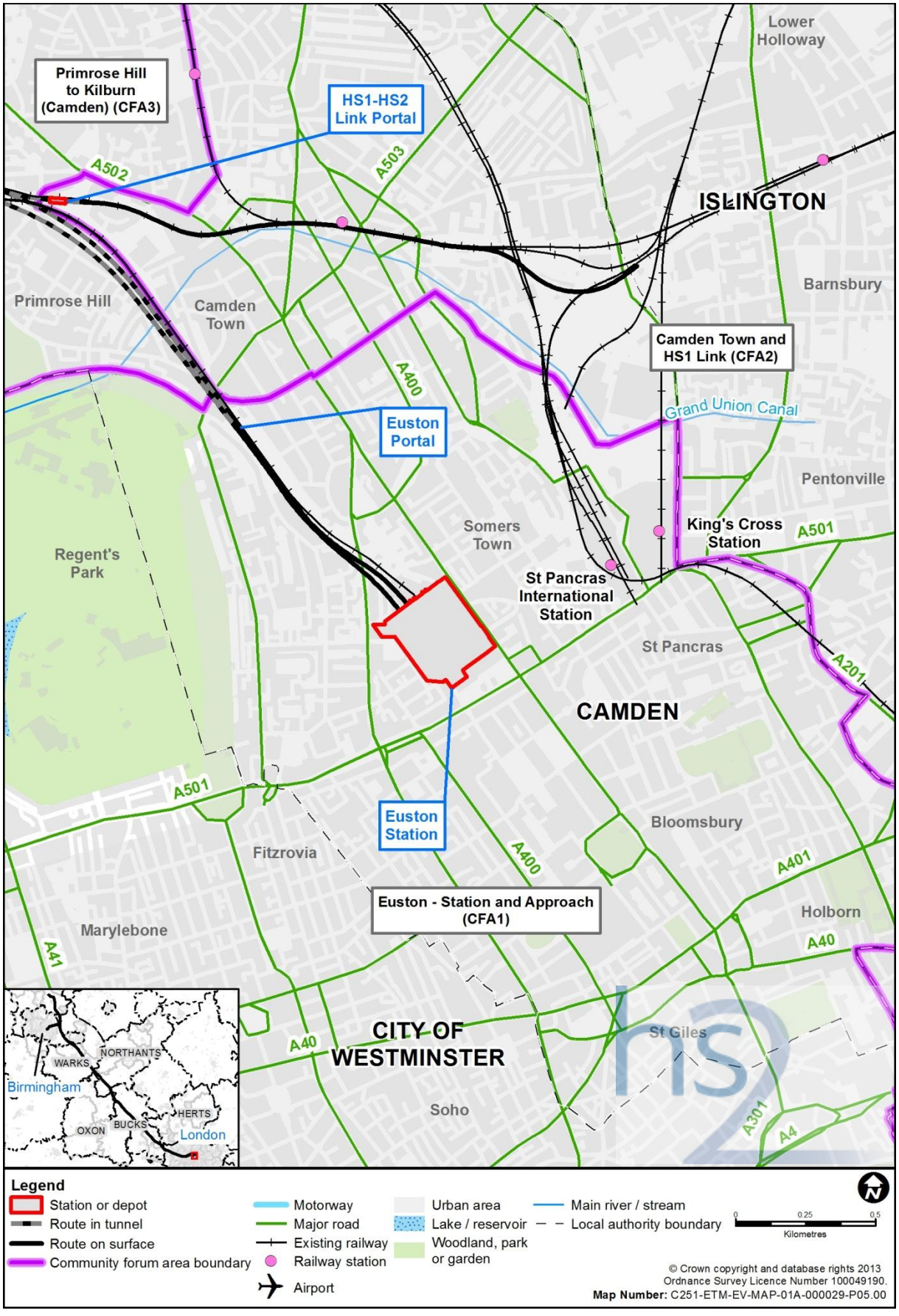
1.3 Location

1.3.1 CFA1 comprises Euston Station and a 1.3km section of the route from Euston Station north of the Euston Road to the Park Street Tunnels, where Parkway crosses the existing railway. This area is adjacent to the Primrose Hill to Kilburn (Camden) area (CFA3) to the immediate north-west and the Camden Town and HS1 Link area (CFA2) to the north, as shown in Figure 1.

1.3.2 CFA1 lies at the south-eastern end of the Proposed Scheme and is entirely within the London Borough of Camden (LBC). The study area extends to a distance of 500m from the centre line of the route.

[1] Department for Communities and Local Government (2012), *National Planning Policy Framework.*

Figure 1: Euston – Station and Approach area



2 Flood risk assessment methodology

2.1 Source-pathway-receptor model

2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model individual sources of flooding within the study area are identified. The primary source of flooding is rainfall which is a direct source in the short-term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewer flooding) in the short or medium-term. Stored rainfall, either naturally in below ground aquifers and natural lakes or artificially in impounded reservoirs and canals, can lead to flooding when the storage capacity of the system is exceeded. A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea.

2.1.2 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.

2.1.3 Receptors considered in this assessment include the Proposed Scheme and existing development within 500m of the Proposed Scheme. The Proposed Scheme includes all associated permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified mitigation is proposed in line with recommendations in the NPPF.

2.1.4 Existing receptors within the study area are identified using Ordnance Survey (OS) mapping information. A high-level screening assessment is then undertaken to identify receptors that are within or in close proximity to an area of flood risk via pathways indicated using the flood risk data sources listed below. The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document[2].

2.1.5 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the Proposed Scheme has any potential to influence or alter the risk of flooding to each receptor. Where such potential has been identified, mitigation is proposed based on further analysis.

2.2 Flood risk categories

2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

[2] Department for Communities and Local Government (2012), *National Planning Policy Framework Technical Guidance.*

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	**Low**	**Medium**	**High**	**Very high**
Rivers		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water	No surface water flooding.	Surface water flooding <0.3m for 1 in 200 years event.	Surface water flooding >0.3m for 1 in 200 years event; and Surface water flooding <0.3m for 1 in 30 years event.	Surface water flooding >0.3m for 1 in 30 years event.	
Groundwater		Very low-low	Moderate	High-very high	
Drainage and sewer systems	No sewer in vicinity of site.	Surcharge point >20m from site and no pathways.	Surcharge point within 20m of site and restricted pathways.	Sewer network crosses site and pathways exist.	
Artificial sources	Outside of inundation mapping/no pathway exists.	Within inundation mapping/ pathway exists.			

2.3 Regional and local flooding planning policy documents

2.3.1 The lead local flood authority (LLFA) is LBC which is also the local planning authority for CFA1. The recommendations from the LBC Preliminary Flood Risk Assessment (PFRA)[3] have been reviewed in undertaking this assessment. The LBC Local Flood Risk Management Strategy (LFRMS)[4] was approved in June 2013.

2.3.2 LBC, acting as the local planning authority, has also produced a strategic flood risk assessment (SFRA) [5] in conjunction with a number of surrounding local authorities.

London Borough of Camden Preliminary Flood Risk Assessment

2.3.3 The LBC PFRA indicates that there have been no identifiable past floods in the borough that have had significant harmful consequences. Future flood risk in the borough, however, is estimated to be high based on the Drain London surface modelling outputs.

2.3.4 The LBC PFRA confirms that the extent of the Greater London indicative flood risk area is correct within the borough and that the entire borough lies within the indicative flood risk area. Further stages of the Flood Risk Regulations 2009[6] process

[3] Halcrow (2011), *London Borough of Camden Preliminary Flood Risk Assessment.*
[4] London Borough of Camden (2013), *Managing flood risk in Camden: The Camden flood risk management strategy.*
[5] Mouchel (2008*), North London Strategic Flood Risk Assessment.*
[6] *Flood Risk Regulations 2009* (SI 2009 No. 3042), London, Her Majesty's Stationery Office.

(i.e. flood risk mapping and flood risk management plans) will therefore be undertaken by the LLFA in due course. The LBC PFRA states that the current locally agreed spatial surface water flood risk information dataset is from the modelling activities undertaken as part of the Drain London project.

London Borough of Camden Local Flood Risk Management Strategy

2.3.5 The LBC LFRMS guides the planning process in relation to flood risk across all categories and outlines key policies in relation to development within LBC. The strategy aims to:

- understand and explain the level of risk affecting the residents and businesses of Camden;
- provide an action plan for areas at particular risk from surface water flooding;
- highlight the actions that all partners, businesses and residents in Camden should be taking to manage flood risk; and
- take a sustainable and holistic approach to flood management, seeking to deliver wider environmental and social benefits.

Thames Region Catchment Flood Management Plan

2.3.6 The Thames Region Catchment Flood Management Plan[7] (CFMP) sets out policies for the sustainable management of flood risk across the Thames catchment over the coming 50-100 years taking climate change into account. CFA1 lies within the TE2100 Policy Unit, and the preferred policy is Policy 4 which includes areas of low, moderate or high risk where the Environment Agency is already managing the flood risk effectively but where further action may need to be taken to keep pace with climate change.

2.3.7 The Thames Region CFMP states that the most sustainable approach to managing future flood risk will be to bring about adaptation of the urban environment. It indicates that strategic scale planning is key to achieving the needs of the community and managing flood risk in a more sustainable way, and that emergency planning is integral to the approach to managing extreme flood events.

London Regional Flood Risk Appraisal

2.3.8 The London Regional Flood Risk Appraisal[8] (RFRA) provides a broad regional understanding of the risk of flooding in Greater London to feed into each of the LLFA SFRA and PFRA reports. Recommendation 7 states that regeneration and redevelopment of London's river corridors offers a crucial opportunity to reduce flood risk in these areas.

London Plan

2.3.9 Policy 5.12 of the London Plan[9] states that development proposals must comply with flood risk assessment and management requirements set out in the NPPF. Policy 5.13

[7] Environment Agency (2008), *Thames Catchment Flood Management Plan.*
[8] Greater London Authority (2009), *London Regional Flood Risk Appraisal.*
[9] Greater London Authority (2011), *London Plan.*

states that development should utilise sustainable drainage systems (SuDS), aiming to achieve greenfield runoff rates unless there are practical reasons why they should not be used.

North London Strategic Flood Risk Assessment

2.3.10 The North London SFRA was completed in 2008 as part of the evidence base for the North London Waste Plan. LBC is one of seven participating boroughs that are included in the report. The North London SFRA states that LBC has a particularly high risk of flooding from sewer and surface water sources, while river flood risk remains low due to the lack of watercourses.

London Borough of Camden Core Strategy

2.3.11 Policy CS13 of the LBC adopted Core Strategy[10] seeks to make Camden a water efficient borough and minimise the potential for surface water flooding by requiring development to avoid harm to the water environment, water quality or drainage systems and prevent or mitigate local surface water and down-stream flooding, especially in areas up-hill from, and in, areas known to be at risk from surface water flooding.

London Borough of Camden Adopted Development Policies

2.3.12 Policy DP23 of the LBC adopted Development Policies[11] requires that developments reduce their water consumption and the risk of flooding by:

- incorporating water efficient features and equipment;
- limiting the amount and rate of runoff and waste water to reduce the risk of flooding;
- reducing the pressure placed on the storm water and sewer network; and
- ensuring that development is assessed for upstream and downstream groundwater flood risks in areas where historic underground streams are known to have been present.

2.3.13 Policy DP23 requires all new developments in areas identified as having a risk of surface water flooding in LBC to achieve a greenfield rate of runoff. All other development that increases the amount of impervious surface is expected to minimise the amount and rate of runoff from the site to at least the existing rate. The Proposed Scheme will pass through areas that are identified as having historically flooded within LBC during the 1975 and 2002 events. It will not pass through areas however, with the potential to be at risk of surface water flooding as shown in Map 2 within the LBC adopted Development Policies document.

2.3.14 Policy DP22 requires development to be resilient to climate change by ensuring schemes include appropriate adaptation measures, such as limiting runoff and reducing water consumption.

[10] London Borough of Camden (2010), *Adopted Core Strategy*.
[11] London Borough of Camden (2010), *Adopted Development Policies*.

3 Design criteria

3.1.1 It is a requirement of the design that the Proposed Scheme shall be protected against flooding from any source during the 1 in 1,000 years return period (0.1% annual probability) rainfall event with water levels not rising closer than 1m to the top of rail level.

3.1.2 In accordance with the NPPF an allowance for climate change is included in the assessment by assuming that peak rainfall intensity will increase by 30%, and that peak river flows will increase by 20%.

4 Data sources

4.1 Primary datasets

4.1.1 Consistent with the requirements of the NPPF this assessment considers the risk of flooding from rivers, direct surface water runoff, rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.

4.1.2 The Proposed Scheme lies entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.

4.1.3 The primary datasets for each source of flooding used to assess the design elements are presented in Table 2. A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the line, further investigation in the form of hydraulic modelling is undertaken.

Table 2: Flood risk assessment data sources

Source of flooding	Datasets reviewed	Data owner
Rivers	Flood zone mapping. Detailed River Network (DRN). Catchment hydraulic models.	Environment Agency
Surface water	Flood Map for Surface Water (FMfSW). Local surface water flood mapping.	Environment Agency LLFA
Groundwater	Areas susceptible to groundwater flooding. 1:50,000 geological mapping (superficial and bedrock). Potential for elevated groundwater.	British Geological Survey (BGS) LLFA
Drainage and sewer systems	Sewer network plans. Lost river location plans.	Thames Water Utilities Limited (TWUL) Local planning authority
Artificial sources	Reservoir inundation mapping. Canal infrastructure locations. Trunk water main asset plans.	Environment Agency Canal & River Trust TWUL

4.2 Site familiarisation visits

4.2.1 No site familiarisation visits were undertaken within CFA1.

5 The proposed development

5.1 Topography and land use

5.1.1 The topography of the study area within CFA1 is generally flat with a gentle rise of approximately 15m from Euston Station to Parkway. The area is predominantly urban in character and is dominated by commercial and residential buildings.

5.1.2 Euston Station, the West Coast Main Line (WCML), and associated operational and maintenance facilities are key elements of the urban environment in the area. The existing railway corridor runs north-west in cutting from Euston Station, through the districts of Somers Town to the east and Regent's Park to the west.

5.2 Local flood risk receptors

5.2.1 The vulnerability of each local receptor with an identified pathway within the study area is presented in Table 3. The vulnerability is classified in accordance with the recommendations of Table 2 in the NPPF Technical Guidance Document and the Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-000/1) and the SMR Addendum (see Volume 5: Appendix CT-001-000/2).

Table 3: Vulnerability of local receptors in CFA1

Local receptor	Description	Vulnerability classification	Source/pathway
University College Hospital	Hospital	More vulnerable	Surface water 200 years - deep
Euston Tap Public House	Public house	Less vulnerable	Surface water 200 years - deep
University College London (UCL)	Educational establishment and halls of residence	More vulnerable	Surface water 200 years - deep
Walkden House, Melton Street	Railway infrastructure	More vulnerable	Surface water 200 years - deep
Regnart Buildings	Residential dwellings	More vulnerable	Surface water 200 years - deep
Dwellings on Taviton Street and Endsleigh Street	Residential dwellings	More vulnerable	Surface water 200 years - deep
Premier Inn, Euston Road	Hotel	More vulnerable	Surface water 200 years - deep
Drummond Crescent and Church Way, Somers Town	Residential dwellings including basement dwellings	Highly vulnerable	Surface water 30 years - deep
Dwellings to the north and west of St James's Gardens	Residential dwellings including basement dwellings	Highly vulnerable	Surface water 200 years - deep
Buildings to the east and west of Hampstead Road	Commercial properties	Less vulnerable	Surface water 200 years - deep

5.3 Description of the Proposed Scheme

5.3.1 Euston will be the London terminus for the Proposed Scheme. The existing station will be expanded and remodelled to accommodate high speed train services as well as the existing WCML and local conventional rail services. The combined station will become

the centrepiece and catalyst for the regeneration and development of the Euston area.

5.3.2 Much of the existing station used by conventional trains will be retained and refurbished. The concourse and platforms for high speed trains will replace the western part of the existing station and extend further to the west than the existing station. The high speed and conventional rail concourse will operate as one combined space (see Map CT-06-001, Volume 2 CFA1 Map Book).

5.3.3 The provision of platforms for high speed trains at Euston will require widening of the existing railway retained cutting to the north of Euston Station, to the west of the existing tracks. The high speed tracks will enter the proposed twin bore tunnel at a deeper level than the existing railway.

6 Existing flood risk

6.1 Historical flooding incidents

6.1.1 The Camden PFRA does not identify any past floods within this study area that have had significant harmful consequences that would be reportable to the European Union (EU).

6.1.2 The North London SFRA reports that a large area in the north of Camden was affected by surface water flooding in August 2002 which was the result of heavy rainfall inundating the public sewer system. A similar area of Camden was affected by surface water/sewer flooding in 1975. Euston Station was forced to close during the 2002 event. The station itself, however, was not recorded to have flooded in this event[12].

6.1.3 The Camden PFRA states that sewer flooding occurred within the borough in August 2004, September 2005 and July 2007. Specific locations of these flood incidents are not provided in the document.

6.1.4 The North London SFRA reports that no groundwater flooding incidents have been recorded by the Environment Agency in LBC.

6.2 Risk of flooding from rivers

6.2.1 The Proposed Scheme will not intersect with any Environment Agency designated main rivers or ordinary watercourses within this study area, and the entire study area is within Flood Zone 1. Therefore there is a low risk of flooding to the Proposed Scheme from rivers.

6.3 Risk of flooding from surface water

6.3.1 The Drain London modelling outputs and the Environment Agency FMfSW have been reviewed to form the basis of the assessment of the risk of surface water flooding. In general each of the LLFAs reports a good correlation between the FMfSW and the Drain London modelling. The Drain London modelling, however, considers the underground drainage infrastructure in a higher level of detail and is considered to be the superior dataset. The Environment Agency FMfSW is shown on Map WR-01-001 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

6.3.2 There are areas within CFA1 that have a high risk of surface water flooding. This assessment focuses on the areas at risk of surface water flooding adjacent to the Proposed Scheme.

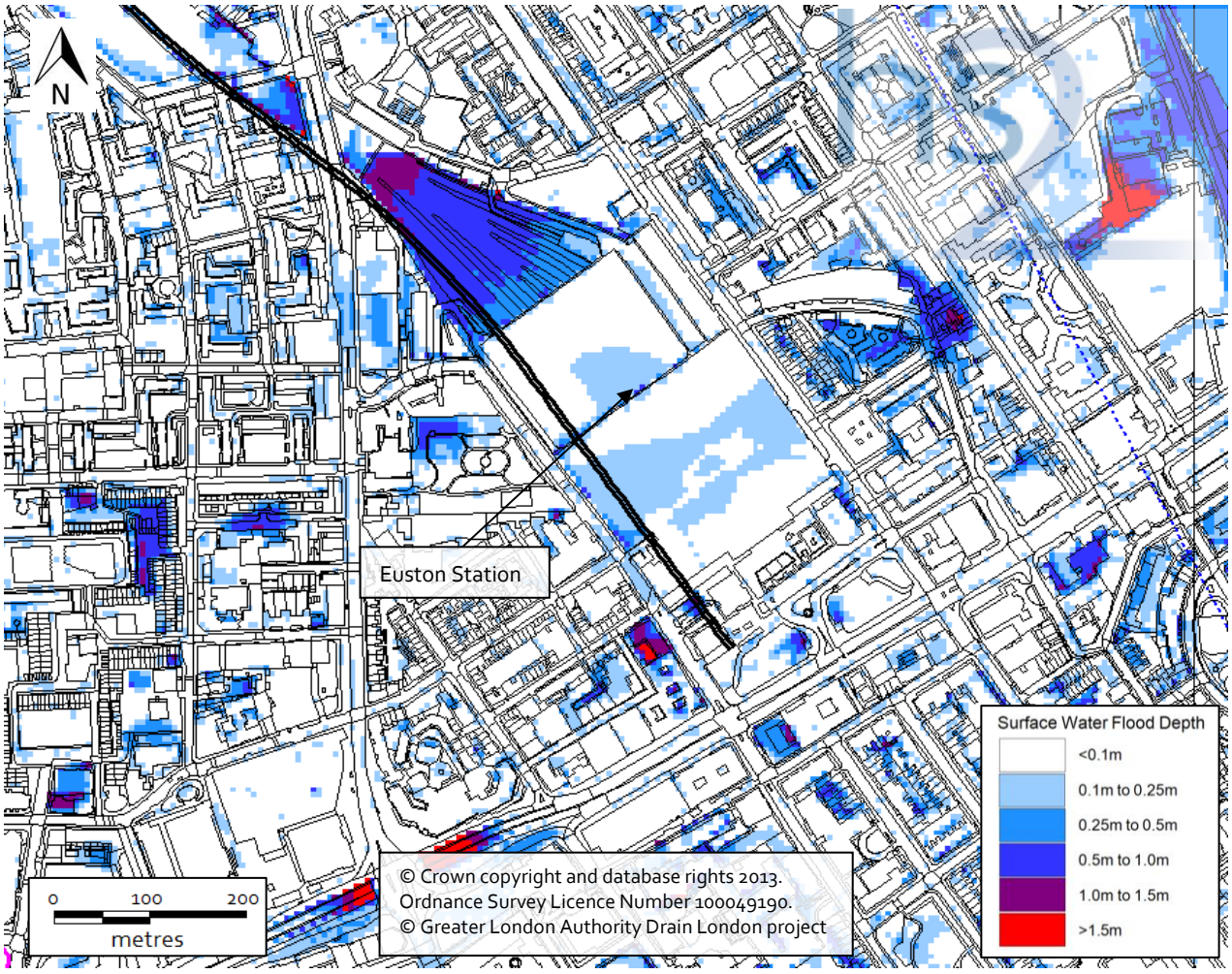
Euston Station

6.3.3 Surface water flooding datasets from the LBC PFRA show parts of the rails of the WCML and London Overground (LO) lines, immediately to the north of Euston Station, to be at risk of flooding during the 1 in 200 years return period (0.5% annual probability) flood event to depths up to 1.5m, as shown in Figure 2. These areas are

[12] London Borough of Camden (2003), *Floods in Camden: Report of the Floods Scrutiny Panel.*

also at risk of surface water flooding during the 1 in 30 years return period (3.33% annual probability) flood event. Euston Station will be extended to the west, with the extended station approximately 70m wider than the existing.

Figure 2: 1 in 200 years return period (0.5% annual probability) surface water flood depth at Euston Station from Drain London dataset



6.3.4 The existing track level of the WCML is between 19m above Ordnance Datum (AOD) and 20m AOD throughout this area at risk of surface water flooding. Surrounding ground levels are at approximately 24m AOD. The high speed platforms and lines will be around 6.5m lower than the WCML. A flood wall will be provided in the design to separate the high speed tracks and platforms from the conventional tracks and platforms. The height of this flood wall will be 1m. This is based on surface water flooding datasets and will include a freeboard to allow for modelling uncertainty and unforeseen effects. This will ensure that the sub-catchments are separated thereby reducing the risk of surface water flooding at this location to low.

6.3.5 To the west of the existing station there are areas at risk of surface water flooding. These areas are isolated and do not form part of a wider surface water flow path. Euston Station is to be extended to the west and will intercept some of these areas of surface water flooding. Based on light detection and ranging (LiDAR) information the areas of flooding are associated with topographic low points and are at approximately 22m AOD. The threshold to the station concourse will be at approximately

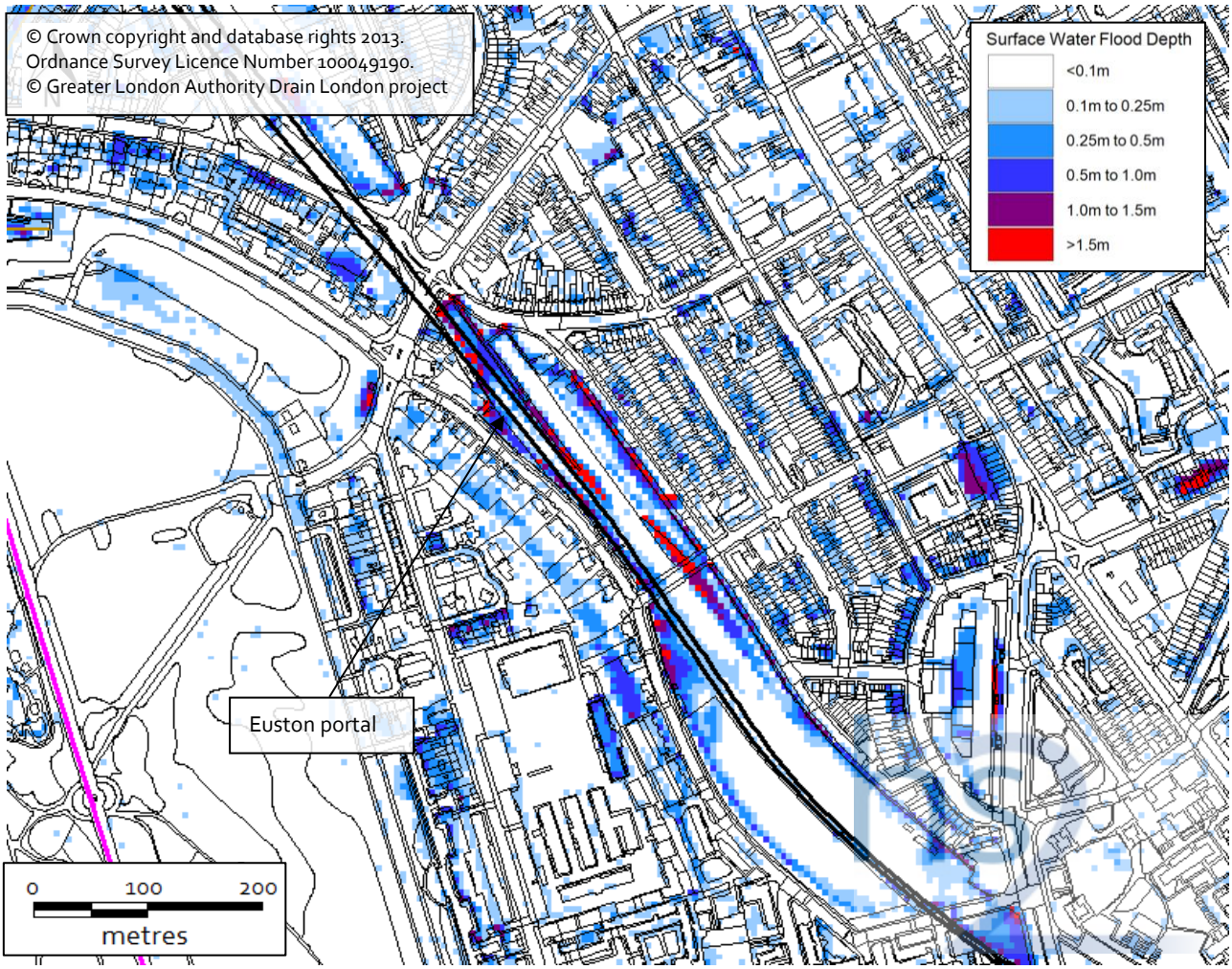
24.5m AOD and will prevent the entry of floodwater to the excavation. Rainfall within the station excavation itself will be managed by the Proposed Scheme drainage network.

6.3.6 As a result, there will be no significant risk of surface water flooding to the Proposed Scheme at the Euston Station.

Euston portal

6.3.7 Further to the north-west within the existing excavation of the WCML and LO tracks there are areas shown to be at risk of flooding during the 1 in 200 years return period (0.5% annual probability) flood event to depths up to 1.5m, as shown in Figure 3. These areas are also at risk of surface water flooding during the 1 in 30 years return period (3.33% annual probability) flood event. In this location the tracks of the WCML and LO are at multiple levels, with a dive under proposed in cutting more than 6m lower than surrounding levels.

Figure 3: 1 in 200 years return period (0.5% annual probability) surface water flood depth at the Euston portal from Drain London dataset



6.3.8 Euston portal will be located within the existing WCML cutting, adjacent to the current dive under. The dive under will be backfilled, thereby reducing the risk of flooding in these local depressions. A parapet wall will be installed along the top of the contiguous bored pile wall to separate the portal excavation from the surrounding area. This will ensure that there will be segregation in the respective high speed and

conventional rail catchments, and will prevent surface water flooding from entering the tunnel portal.

6.3.9 There will be no significant risk of surface water flooding to the Proposed Scheme at the Euston portal.

6.4 Risk of flooding from groundwater

6.4.1 According to the LBC PFRA, there is an area to the immediate south of Euston Station that is shown to have an increased potential for groundwater emergence. This area is associated with the superficial Lynch Hill Gravel deposits. This area is confirmed in the BGS susceptibility to groundwater flooding dataset.

6.4.2 The CFA1 Water Resources Assessment (Volume 5: Appendix WR-002-001) concluded that recharge to the Lynch Hill Gravel will be limited as the predominant land cover is impermeable. Groundwater levels in the deposits are therefore likely to be low. Drainage will be provided to dewater the excavation if local perched groundwater is encountered. Consequently, there will be a low risk of groundwater flooding to the Proposed Scheme within the study area.

6.5 Risk of flooding from drainage systems

6.5.1 The Proposed Scheme will pass through heavily urbanised areas within the study area and therefore above ground infrastructure will be located close to the existing sewerage network and associated manholes. The LBC PFRA and LBC SFRA report a number of historical incidents of sewer flooding, however, the exact location of these incidents is not available.

6.5.2 The sewer network in this area is predominantly combined (i.e. conveys both foul water and surface water). In the event of surcharging within the sewer network, the areas at risk of flooding are comparable to those at risk of surface water flooding, described in Section 6.3 of this report.

6.5.3 There are large diameter sewers in the vicinity of Euston Station associated with the historical alignment of the River Fleet. These are connected to the local public sewer network.

6.5.4 The large diameter trunk sewers and storm relief sewers will be assessed to determine their structural stability prior to commencement of tunnelling works. Any mitigation required to prevent the collapse of the sewers will be installed prior to tunnelling.

6.5.5 There will therefore be no significant risk of flooding from drainage and sewer systems to the Proposed Scheme within the study area further to the risk from surface water described in Section 6.3 of this report.

6.6 Risk of flooding from artificial sources

Canals

6.6.1 The Grand Union Canal (Regent's Canal) lies within the study area to the north of Regent's Park. However, the crossing of the canal (SWC-CFA3-01) is located within

CFA3, as shown on Map WR-01-003 (Volume 5, Water Resources and Flood Risk Assessment Map Book), and is therefore not considered further in this FRA.

Reservoirs

6.6.2 Within the study area there are no areas that are shown to have a residual risk of flooding from failure of impounded reservoirs. There will be no risk of flooding to the Proposed Scheme as a result of a failure of impounded reservoirs.

Water mains

6.6.3 The Proposed Scheme will cross a number of TWUL water supply mains within the study area. At the majority of locations, the Proposed Scheme will be in a tunnel, and in these cases, there will be no significant risk of flooding to the Proposed Scheme.

6.6.4 There are trunk water mains in the streets surrounding the existing Euston Station. There is a 1,067mm diameter cast iron water main in the carriageway of Euston Road, a 1,067mm diameter cast iron water main in Melton Street, and a 406mm diameter cast iron water main in Eversholt Street. The excavation for the extension to Euston Station will involve the abandonment and diversion of the water main in Melton Street. The diversion will be undertaken using a material of higher tensile strength than cast iron, and thence better able to withstand differential ground movements.

6.6.5 There is a further 406mm diameter cast iron water main within the bridge deck of the Hampstead Road Bridge, and a 1,067mm diameter cast iron water main in the bridge deck of Mornington Street Bridge. These bridges will be demolished and replaced, with the replacement water mains constructed using more ductile materials that are able to withstand some movement of the bridge deck. Therefore the risk of flooding due to a failure of a water main is low.

6.6.6 Two water mains are identified as being within the carriageway of the A4201 Parkway at the boundary between CFA1 and CFA3, the diameters of which are both 914mm. Euston portal will lie approximately 120m to the south. There is a wall at the edge of the bridge over the existing WCML. In addition, a parapet wall will be constructed at the edge of the portal excavation to separate the surface water catchments. Should either of these mains in the A4201 fail, this wall will prevent the flooding of the tunnels.

6.6.7 The risk of flooding to the Proposed Scheme from these water mains is therefore low.

6.7 Summary of baseline flood risk

Table 4: Summary of baseline flood risk for all sources of flooding in CFA1

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Surface water	WCML and LO track beds on approach to Euston Station	High Drain London 30 years - deep 200 years - deep	Euston Station	Parapet wall will be provided to separate surface water catchments - low risk
			Euston portal	Parapet wall will be provided to separate surface water catchments - low risk
Groundwater	Lynch Hill Gravel to south-west of Euston Station	High	Euston Station	Excavation will lie at edge of flood risk area with drainage provided - low risk
Artificial sources (water mains)	Euston Road and A4201	Low	Euston Station	Walls along bridge extent and parapet wall will protect excavation - low risk

7 Flood risk management measures

7.1 Risk of flooding from rivers

7.1.1 There will be no risk of flooding from rivers to the Proposed Scheme, nor any anticipated effects on the risks of flooding from rivers within the study area arising from the Proposed Scheme. Therefore, no specific mitigation will be required.

7.2 Risk of flooding from surface water

7.2.1 A flood wall will be provided within the design to ensure that the drainage sub-catchments are separated. This will minimise the risk of flooding to the Proposed Scheme from the surrounding conventional rail lines and also prevent any increase in the volume of surface water that could arise from the Proposed Scheme collecting in the tracks of the conventional rail at Euston Station. No further specific mitigation will be required. There will not be any anticipated changes to the risk of flooding from surface water sources as a result of the Proposed Scheme within CFA1; therefore no further mitigation will be required.

7.3 Risk of flooding from groundwater

7.3.1 There will be no significant risk of flooding from groundwater to the Proposed Scheme, nor any anticipated effects on the risks of flooding from groundwater within the study area arising from the Proposed Scheme. Therefore, no specific mitigation will be required.

7.4 Risk of flooding from drainage systems

7.4.1 There will be no significant risk of flooding from drainage systems to the Proposed Scheme, nor any anticipated effects on the risks of flooding from drainage systems within the study area arising from the Proposed Scheme. Therefore, no specific mitigation will be required.

7.5 Risk of flooding from artificial sources

7.5.1 There will be no significant risk of flooding from artificial sources to the Proposed Scheme, nor any anticipated effects on the risks of flooding from groundwater within the study area arising from the Proposed Scheme. Therefore, no specific mitigation will be required.

8 Post-development flood risk assessment

8.1 Local receptors

8.1.1 In addition to the risk of flooding that exists to the Proposed Scheme, there is potential for the Proposed Scheme to affect the risk of flooding to third party receptors by altering flow mechanics across the range of flood sources. All local receptors with a potential flood risk are identified in Section 5.2 of this report. For the Proposed Scheme to have an impact on a given receptor, the identified pathway for that receptor must be shared by both the subject receptor and the Proposed Scheme, with the result that a number of cases can be excluded immediately. Table 5 summarises the shared pathways between the Proposed Scheme and each receptor, and identifies cases where no shared pathway exists.

Table 5: Shared flood risk pathways in CFA1

Local receptor	Vulnerability classification as per the NPPF	Pathway	Shared pathway between Proposed Scheme and receptor
University College Hospital	More vulnerable	Surface water 200 years - deep	No shared pathway.
Euston Tap Public House	Less vulnerable	Surface water 200 years - deep	No shared pathway.
UCL	More vulnerable	Surface water 200 years - deep	No shared pathway.
Walkden House, Melton Street	More vulnerable	Surface water 200 years - deep	No shared pathway.
Regnart Buildings	More vulnerable	Surface water 200 years - deep	No shared pathway.
Dwellings on Taviton Street and Endsleigh Street	More vulnerable	Surface water 200 years - deep	No shared pathway.
Premier Inn, Euston Road	More vulnerable	Surface water 200 years - deep	No shared pathway.
Drummond Crescent and Church Way, Somers Town	Highly vulnerable	Surface water 30 years - deep	No shared pathway.
Dwellings to the north and west of St James's Gardens	Highly vulnerable	Surface water 200 years - deep	Euston Station
Buildings to the east and west of Hampstead Road	Less vulnerable	Surface water 200 years - deep	Euston Station

8.1.2 There is also the potential for the Proposed Scheme to change the baseline risk of flooding described in Section 6 of this report. Though designed such that the probability of the Proposed Scheme flooding in any given year is less than 1 in 1,000, any change to the baseline risk of flooding could impact on the assessment of flood risk to the Proposed Scheme. All cases of flood risk discussed in Section 6 of this report are therefore reconsidered regardless of the presence or otherwise of third party local receptors.

8.2 Impact on risk of flooding from rivers

8.2.1 The Proposed Scheme will not cross any Environment Agency designated main rivers or ordinary watercourses within CFA1 and the Proposed Scheme will, therefore, not lead to a change in the risk of flooding local receptors from rivers.

8.3 Impact on risk of flooding from surface water

8.3.1 Any above ground infrastructure has the potential to alter overland surface water flow routes, thereby changing the risk of flooding to local receptors through displacement of flood waters and alteration to flow conveyance times.

Euston Station

8.3.2 There will be extensive development to above ground infrastructure at Euston Station with a 70m extension of the station excavation to the west. Although the Euston area is heavily urbanised this development will lead to an increase in the amount of impermeable area.

8.3.3 The construction area will be separated into sub-catchments for the purpose of managing surface water. The flood wall between the conventional and high speed tracks will ensure that there is no increase in the risk of surface water flooding to the Network Rail tracks in Euston Station.

8.3.4 Rainfall will be collected within the sub-catchments and will be attenuated to 50% of the calculated existing runoff rate. Attenuation will be in the form of underground storage tanks with outfalls to the existing TWUL sewers on Eversholt Street and Cobourg Street. Attenuation volumes of approximately 3,900m^3 will be required for the Euston Station area, and a further 2,700m^3 will be required for the high speed tracks that will drain towards the station. Any connection and allowable discharge rates will be agreed in advance with TWUL.

8.3.5 Surface water flooding in the area surrounding the extended Euston station is formed of isolated areas of ponding in low topographic points. There is no connectivity between these areas. Some of the deepest areas of predicted surface water flooding will be within the boundary of the station extension. Rain falling in these areas will be collected within the station drainage system. There will be no deflection of overland flow in this area and there will be, therefore, no increase in the risk of flooding from surface water outside of the station footprint.

8.3.6 The Proposed Scheme will not significantly affect the risk of surface water flooding at or in the vicinity of Euston Station.

Euston portal

8.3.7 A new dive under will be constructed as part of the Proposed Scheme to the north of Granby Terrace Bridge. The existing dive under which serves conventional rail tracks, located on either side of Mornington Street Bridge will be abandoned and will be backfilled.

8.3.8 Rainfall will be collected and will be attenuated to 50% of the calculated existing runoff rate. Attenuation will be in the form of underground storage tanks within the

portal structure and will be pumped to a new outfall with the TWUL sewer on Cobourg Street. Attenuation volumes of approximately 800m^3 will be required for runoff draining towards the portal. Any connection and allowable discharge rates will be agreed in advance with TWUL.

8.3.9 There are no construction works outside of existing rail land in this area that have the potential to affect the risk of surface water flooding.

8.3.10 Therefore, the Proposed Scheme will not significantly affect the risk of surface water flooding at or in the vicinity of the Euston portal.

8.4 Impact on risk of flooding from groundwater

8.4.1 The excavation at Euston Station within the superficial Lynch Hill Gravel deposits is relatively minor and is on the periphery of the deposits. Given the urban nature of the surrounding land there is likely to be very limited recharge to these deposits. The CFA1 Water Resources Assessment (Volume 5: Appendix WR-002-001) concluded that there will be no significant change in groundwater levels or flows within these deposits. Therefore, the Proposed Scheme will not impact on groundwater levels and consequently there will be no effect on the risk of flooding from groundwater within the study area.

8.5 Impact on risk of flooding from drainage systems

8.5.1 Connections to the foul and surface water sewer network from Euston Station and Euston portal will be agreed with TWUL in order to avoid creating additional burden on the existing sewer networks. There will not be a significant increase in the area of impermeable surface following construction as the sites are already developed. The Proposed Scheme will therefore not lead to a change in the risk of flooding from drainage and sewer systems within the study area.

8.5.2 Any dewatering from the Lynch Hill Gravel deposits south of Euston Station will be discharged to the existing sewer networks, potentially increasing the load. Discharge rates for dewatering will be agreed in advance with TWUL, which will avoid creating a significant additional burden. Consequently, the Proposed Scheme will not result in an increase in the risk of flooding from drainage and sewer systems due to dewatering discharges.

8.6 Impact on risk of flooding from artificial sources

Canals

8.6.1 The potential impacts on the risk of flooding from the Grand Union Canal (Regent's Canal) is within the flood risk assessment for CFA3 (Volume 5: Appendix WR-003-003) where this canal is crossed by the Proposed Scheme.

Impounded reservoirs

8.6.2 There are no areas with a risk of flooding due to the failure of impounded reservoirs within the study area and therefore there will be no change in the risk of flooding from reservoirs as a result of the Proposed Scheme.

Water mains

8.6.3 The settlement of the ground along the length of all water mains due to tunnelling, and the potential damage to the pipes due to additional strain in the material, will be assessed prior to and during construction. Although there is an increased risk of failure during construction, this will be managed as part of the construction programme. So long as construction is appropriately managed, the risk of failure of these water mains in the permanent case will not be increased as a result of the Proposed Scheme.

8.7 Summary of potential impacts and effects on flood risk

Table 6: Summary of potential flood risk impacts and effects in CFA1

Receptor	Vulnerability classification	Pathway	Impacts and effects
General Proposed Scheme	N/A	Rivers	No effects expected.
		Surface water	Rainfall to be collected, attenuated and discharged to existing sewerage infrastructure. No effects expected.
		Groundwater	No effects expected.
		Drainage systems	Surface and foul discharges at Euston Station to be collected, attenuated and discharged to existing sewerage infrastructure. No effects expected.
		Artificial sources	No effects expected.
Dwellings to the north and west of St James's Gardens	Highly vulnerable	Surface water 200 years - deep	To be demolished. Drainage to be separated and surface water flooding modelled. No effects expected.
Buildings to the east and west of Hampstead Road	Less vulnerable	Surface water 200 years - deep	To be demolished. Drainage to be separated and surface water flooding modelled. No effects expected.

9 Conclusions

9.1 Summary

9.1.1 The Proposed Scheme within CFA1 extends from the existing Euston Station to the A4201 Parkway. The study area includes all areas within 500m of the Proposed Scheme, which includes areas at risk of flooding from the following sources:

- areas at risk of surface water flooding surrounding Euston Station; and
- areas with a risk of flooding due to the failure of trunk water mains.

9.1.2 Drainage will be provided to ensure that the top of rail levels of the Proposed Scheme will be at least 1m above design flood water levels within all areas at risk of flooding. Residual risks from these sources will be negligible.

9.1.3 The study area is heavily urbanised, with substantial residential and industrial development within the study area. There are areas at risk of flooding as a result of direct surface water runoff in rainfall events as well as overloaded sewers and failed water mains. All above ground construction will lie outside of the areas at risk and consequently will have no direct impact on the risk of flooding. Surface water runoff at Euston Station will be collected, attenuated and discharged to existing sewers at pre-agreed rates, and will not create an additional burden on the existing drainage infrastructure. The condition of trunk sewers and water mains will be monitored prior to and during construction to ensure no increased risk of failure due to settlement arising from the proposed tunnels. There will be no increased risk of failure to underground surface water infrastructure from the Proposed Scheme in the permanent case.

9.1.4 There will be no significant increase in the risk of flooding to third party receptors arising from the Proposed Scheme.

9.2 Residual flood risks to Proposed Scheme

9.2.1 There will be no significant residual risks of flooding to the Proposed Scheme.

9.3 Residual effects of the Proposed Scheme on flood risk

9.3.1 The Proposed Scheme will not create an additional risk of blockage of sewer systems and will not lie within any area of significant risk of flooding. There will therefore be no significant impact arising from the Proposed Scheme on the residual risk of flooding to third parties.

9.4 Compliance with local planning policy

9.4.1 The Proposed Scheme includes an allowance for future increases in the risk of flooding as a result of climate change by including a 30% increase to rainfall intensities and flows in minor watercourses as recommended in the NPPF Technical Guidance document. Attenuation will be provided to ensure that the rate of runoff from permanent infrastructure, such as at the HS1 Link portal, will not increase as a result of the Proposed Scheme. This will ensure that there will be no increase in the risk of

surface water flooding, especially in areas where a risk currently exists. The Proposed Scheme will be in compliance with the recommendations of the LBC SFRA, Core Strategy and adopted Development Policies.

10 References

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